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Coastal and erosion risk analysis using remote sensing and GIS: A case study in Sile and Agva towns

E. Saroglu, F. Yasa, O. Akcay, H. Abali & N. Musaoglu
Department of Geodesy and Photogrammetry Engineering, Istanbul Technical University, 34469, Ayazaga, Istanbul, Turkey

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ABSTRACT: In this study, coastal and erosion risk are examined for a tourist region. The towns of Sile and Agva, located in Istanbul Anatolian side at the Black Sea coast was selected as study region. The coastline, nearby Istanbul, has natural beauties such as forest and beach; moreover, it becomes an attractive place for tourists, particularly in summer. Thus, urban development and land use changes occur in the region. Turknil river, Goksu and Agva streams, lying between Sile and Agva, cause alteration on the coastline because of the drifted alluvium. In the research, coastline risk was analyzed. To reach this objective, Landsat TM satellite data obtained in 1987, 1992, 1997, and 2001, 1:25000 topographic maps and aerial photos were used in order to detect land use change in temproral scales. In the analysis stage, classification and enhancement algorithms were applied to satellite images, topographic maps were digitized to form a digital elevation model and overlay analysis were made. Consequently, changes in coastline and land cover/land use cover are expressed on an area basis.

1 INTRODUCTION

A lot of natural hazards have been various effect and these hazards cause damage. Increasing casualties that are result of hazards cause to go up importance of taking precaution before disaster. The most important study to prevent or reduce damages of disaster is determination and reduction of hazard risk. Firstly, danger must be determined in order to reduce risks that may exist in different areas of nature. The aim of preventing damage execute works that prevent increase risk which may be caused by danger.

Risk is sometimes taken as synonymous with hazard, but risk has the additional implication of the chance of a particular hazard actually occurring. Risk is the actual exposure of something of human value to a hazard and is often regarded as the product of probability and loss. Thus we may define hazard (or cause) as ‘a potential threat to humans and their welfare’ and risk (or consequence) as ‘the probability of a hazard occurring and creating loss’(Smith, K.).

A variety of effects have parts in natural hazards such as landslides, floods and forest fires. Especially, current status analyses and temporal changes introduce important solutions about the problems that will exist. Satellite images provide an essential data source for current status analysis and temporal change detection. Before the occurrence of the natural hazards, land use information obtained from satellite imagery can be integrated with other kinds of information. Therefore the integration will contribute to determine disaster risk.

In this paper, we attempt a description of the satellite data for risk analysis. We also describe some techniques to determine risk possibilities.

2 STUDY AREA AND DATA

The study area is located in the southwestern part of Turkey.It includes the western part of Black Sea, the Sile and Agva Towns and the mouth of Turknil river, Goksu and Agva streams (Figure 1). The population in the study area is 32.500.

In this study, four Landsat TM images with acquisition dates in 1987, 1992, 1997 and 2001 were acquired in order to analyse changes over time in land cover/land use coverage especially in coastlines.

In addition to satellite data, 1:25.000 scaled topographic maps were available. These maps were used for geometric correction and digital elevation model.

1.5000 scaled aerial photographs were used for visual interpretation and classification.

Figure 1. Location of study area

3 METHODOLOGY

3.1 *Geometric correction*

Raw digital images usually contain geometric distortions because of variations in the altitude, attitude, and velocity of the sensor platform; therefore they cannot be used as a map base without geometric correction (Lillesand and Kiefer).

Accurate geometric correction of multi temporal image set is necessary for overlay analysis, GIS integration, and accurate change detection. In the geometric correction process homogeneously distributed ground control points (GCPs) were selected and reference coordinates of corresponding GCPs were obtained from 1/25000 scaled topographic maps. Mathematical relationship between image coordinates and reference coordinates was established by using first order transformation polynom. The root mean square RMS error for all four rectifications was not permitted to exceed 0,5 pixel.

3.2 *Classification*

All pixels in an image are automatically categorized into land cover classes or themes in image classification procedures (Lillesand and Kiefer). For the purpose of delineating land sea boundary and changes in land cover / land use coverage, unsupervised classification was carried out. ISODATA unsupervised classification technique was used in order to group the pixels into clusters. 100 spectral clusters with 95% convergence value was selected for each image with the aim of performing unsupervised classification.

As a result of classification 7 land cover / land use classes were obtained for 1987, 1992, and 1997 images and these are, sea, coastline, sand (beach), forest, bare land, field, and urban. However, eight classes were obtained for the 2001 image, the additional class was highway class. After forming classified images, accuracy assessment of each classification was carried out.

Accuracy assessment determines the quality of the information derived from remotely sense data. It involves the comparison of a site on a map against reference information for the same site (Congalton and Green).

60 pixels for 1987, 1992, and 1997 images and 65 pixels for the 2001 image were randomly selected with the aim of assessing the accuracy of ISODATA clustering algorithm. Overall accuracy, producer accuracy, and user accuracy of each classification were computed (Table 1,2,3,4). For 2001 Landsat TM image, overall accuracy was found 83.08%. For 1997 Landsat TM image, accuracy was found 83.33%. For Landsat 1992 TM image, accuracy was found 86.67%. And for Landsat 1987 TM image, accuracy was found 91.67%.

Table 1. Accuracy assesment for 2001 Landsat TM image.

Class name	Reference totals	Classified totals	Number correct	Producers accuracy	Users accuracy
Sea	10	10	9	90.00%	90.00%
Coastline	8	10	8	100.00%	80.00%
Sand	5	5	4	80.00%	80.00%
Forest	15	15	13	86.67%	86.67%
Bareland	11	8	7	63.64%	87.50%
Field	6	7	5	83.33%	71.43%
Urban	5	5	4	80.00%	80.00%
Highway	5	5	4	80.00%	80.00%
Totals	**65**	**65**	**54**		

Table 2. Accuracy assessment for 1997 Landsat TM image

Class name	Reference totals	Classified totals	Number correct	Producers accuracy	Users accuracy
Sea	9	10	9	100.00%	90.00%
Coastline	10	10	9	90.00%	90.00%
Sand	5	5	5	100.00%	100.00%
Forest	15	15	14	93.33%	93.33%
Bareland	11	8	7	63.64%	87.50%
Field	6	7	5	83.33%	71.43%
Urban	4	5	4	100.00%	80.00%
Totals	**60**	**60**	**53**		

Table 3. Accuracy assessment for Landsat 1992 TM image

Class name	Reference totals	Classified totals	Number correct	Producers accuracy	Users accuracy
Sea	12	10	10	83.33%	100.00%
Coastline	9	10	8	88.89%	80.00%
Sand	6	5	5	83.33%	100.00%
Forest	13	15	13	100.00%	86.67%
Bareland	9	8	6	66.67%	75.00%
Field	7	7	6	85.71%	85.71%
Urban	4	5	4	100.00%	80.00%
Totals	**60**	**60**	**52**		

Table 4. Accuracy assessment for Landsat 1987 TM image

Class name	Reference totals	Classified totals	Number correct	Producers accuracy	Users accuracy
Sea	10	10	10	100.00%	100.00%
Coastline	10	10	10	100.00%	100.00%
Sand	5	5	4	80.00%	80.00%
Forest	17	15	15	88.24%	100.00%
Bareland	9	8	7	77.78%	87.50%
Field	5	7	5	100.00%	71.43%
Urban	4	5	4	100.00%	80.00%
Totals	**60**	**60**	**55**		

3.3 *Digital elevation model*

A digital elevation model is a digital representation of the terrain surface based on measurements on the reference points (coordinates and elevations known) by means of a software (Tarı, E., 1991).

Slope and aspect analysis, cross sections, topographic information can be obtained from Digital Elevation Models.

In this study, the contour lines were digitized in the 1/25000 topographic map every 20 metres in order to create digital elevation model (Figure 2).

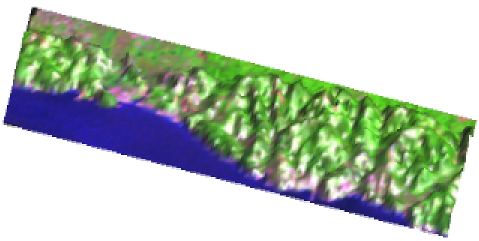

Figure 2. Digital elevation model

3.4 *Overlay*

Overlay is a process which involves the integration or combination of different data layers or maps. Using more than two maps, a new map layer can be produced by overlaying the new output layer gain the attributes of each layer.

In this research, coastline boundaries obtained from classified images and digitized topographic maps were overlaid for determining changes in coastline (Figure 3). Land cover / land use classes obtained from four images were overlaid to see change detection in these classes (Figure 4).

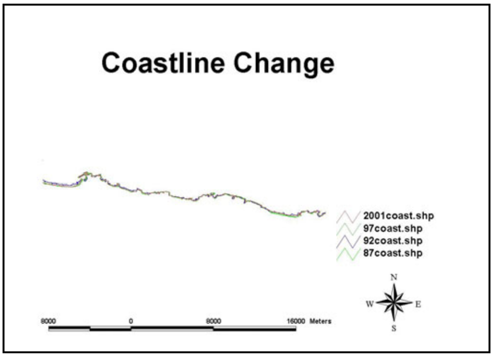

Figure 3. Coastline changes

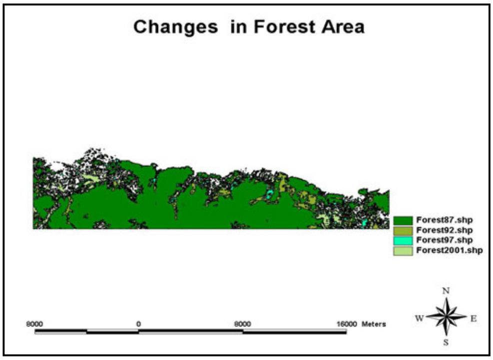

Figure 4. Forest area changes

4 RESULTS

The region between Sile and Agva, located in Istanbul nearby Black Sea coastline, was examined by means of satellite images and a digital elevation model. It was observed that changes have occurred e in the boundary between coastline and land use. Boundary of coastlines obtained from image classification were overlaid in geographic information system and it was demonstrated that coastline changes have occurred from 1987 to 2001. The coastline boundary has gone forward and as a result of this, a decrease in the beach area has occurred.

The area of forest type was found to be 7516.17 ha. in 1987, 8110.17 ha. in 1992, 8429 ha. in 1997, and 8819.28 ha. in 2001 from classification results. On the contrary to forest types, a decrease in field area could be easily seen. The area amount of field was 2387.52 ha. in 1987; however, it was 600.93 ha. in 2001. Natural structure of coastline, changes in land use classes and digital elevation model were evaluated together and it was determined that the ecological structure of the region has been changing. As a result of this, there is an ecological risk in forest and coastline areas in the study region.

Remote sensing is an indispensable technique and resource to identify change detection and contribute to risk management. In addition, creating an information system by using satellite images allows major advantages such as time saving, decision making, and monitoring the results for risk management.

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